

SIXTH EDITION

Introduction to General, Organic, and Biochemistry

Hein • Best • Pattison • Arena

Introduction to General, Organic, and Biochemistry

Sixth Edition

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FRONTIS PHOTOGRAPHS

- ◆ *Green leaves turn red and gold in autumn. As the days grow shorter and the nights grow chilly, the chlorophyll decomposes. The green fades away while other pigments remain, especially the reds and yellows.*
- ◆ *A worker in a pharmaceutical plant monitors the complex and precise machinery used in pill production.*
- ◆ *Chemistry is at work in every aspect of our lives. Scientists can actually see matter at the molecular level by using electron microscopes, and atomic-force microscopes—the first page of this book shows a neuron photographed by an electron microscope.*
- ◆ *Under inspection, a computer chip creates a colorful and intricate maze. These chips are made from the metalloid silicon.*

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*To Morris Hein
Our esteemed colleague and coauthor
whose guidance and dedication
continue to be an inspiration to us.*



Our primary aim in writing *Introduction to General, Organic, and Biochemistry* has been steadfast throughout these six editions—to present chemistry in a clear, engaging manner that will stimulate students to further their scientific knowledge as they prepare for health sciences, nursing, and other careers.

This book is written for students who have not taken chemistry before and may have limited mathematical background and various career objectives. Even though we are constantly and intimately involved in a wide variety of chemical processes, occurring both within our bodies and in our surroundings, chemistry is often considered to be an esoteric subject—not easily accessible to students. Thus, we have portrayed the “everyday” nature of chemistry in photos, illustrations, examples, and in our “Chemistry in Action” series.

In preparing the Sixth Edition we considered the comments and suggestions of students, instructors, and researchers in the chemical education community to design a revision that builds on the strengths of previous editions and presents chemistry as a vital, coherent, and interesting subject. We have especially tried to relate chemistry to the lives of our students as we introduce and develop the principles that form the foundation for the study of general, organic, and biochemistry.

Development of Problem-Solving Skills

We all want our students to develop real skills in solving problems. We believe that the problem-solving approach we take works for students. This problem-solving approach (sometimes called a *dimensional analysis* approach) allows students to use units and show the change from one unit to the next. Students can learn most easily from defining and demonstrating concepts and problems step by step. In this edition we continue to show many examples, beginning with simple substitutions, progressing to the use of algorithms, and moving toward more complex problems. The examples show how to incorporate fundamental mathematical skills, scientific notation, and significant figures by following the rules consistently. Painstaking care has been taken to show each step in the problem-solving process (see pp. 107, 108, 138) and to give *alternative methods for solution* (ratio/proportion, algebraic, for example) where appropriate. These alternate methods give students flexibility in choosing the method that works the best for them. In this edition we have used four significant figures for atomic and molar masses for consistency and for rounding off answers appropriately. We have been careful to follow the rules set down in providing answers, correctly rounded so that students who have difficulty with mathematics do not become confused.

Fostering Student Skills

Attitude plays a critical role in problem-solving. We encourage students to learn that a systematic approach to solving problems is better than simple memorization. We begin to establish this attitude in Chapter 2. Throughout the book we encourage students to begin by writing down what is given (see p. 160) and to think their way through the problem to an answer, which is then checked to see if it makes sense. Once we have laid the foundations of concepts we highlight the steps in blue so students can locate them easily. Important rules and equations are highlighted in colored boxes for emphasis and ready reference.

Dimensional analysis, or factor-label analysis, is explained in section 2.8, p. 23. Beginning students are encouraged to use this approach until they become comfortable with the terms used in calculations.

Alternative methods for solution: See, for example, pp. 38–39 and 178–179.

Problem-solving steps are printed in blue: see pages 149–150, 183–184, and 235 for examples.

Boxed rules and equations: see pages 58, 202, 363, and 745 for examples.

Preface

Practice Problems: see p. 113 for an example and p. 123 for answers.

Questions review key terms, concepts, figures, and tables—see pp. 142–143.

Paired Exercises: pp. 143–145.

Additional Exercises: pp. 145–146.

nitinol: pp. 3–5; **risks and benefits:** pp. 9–10

Student Practice

Practice problems follow most of the examples in the text. Answers are provided at the end of each chapter for all of the practice problems. We have expanded and updated the number of end-of-chapter exercises. Each exercise set begins with a *Questions* section that helps students review key terms and concepts, as well as material presented in tables and figures. These are followed by a *Paired Exercises* section, where two similar exercises are presented side by side. These paired exercises cover concepts as well as numerical exercises. The section called *Additional Exercises* includes further practice on chapter concepts, presented in a more random order. Challenging questions and exercises are denoted with an asterisk. Answers for all even-numbered questions and exercises appear in Appendix V at the end of the book.

Organization

We emphasize the less theoretical aspects of chemistry early in the book, leaving the more abstract theory for later. Atoms, molecules, and reactions are all an integral part of the chemical nature of matter. A sound understanding of these topics will allow the student to develop a basic understanding of chemical properties and vocabulary.

We build toward a basic knowledge of organic and biochemistry for the health science student. Thus, we stress the nomenclature, structure, and reactivity of each major organic functional group. In turn, the basic biochemical concepts rest on this foundation. We encourage the students to apply their understanding to examples drawn from medicine, nutrition, agriculture, etc.

Chapter 1 is completely rewritten in this edition, to give students a better understanding of the scientific process by introducing the course with a narrative account of the discovery of nitinol, often called memory metal. Also included in this chapter is material on the benefits and risks of science in our high tech world.

Chapter 2 presents the basic mathematics and language of chemical calculations, including an explanation of the metric system and significant figures. Chapter 3 introduces the vocabulary of chemical substances, defining matter and the systems of naming and classifying elements. In Chapter 4 we present chemical properties—the ability of a substance to form new substances. Then, in Chapter 5, students encounter the history and terms of basic atomic theory.

We continue to present new material at a level appropriate for the beginning student by emphasizing nomenclature, composition of compounds, and reactions in Chapters 6 through 9 before moving into the details of modern atomic theory (Chapters 10 and 11). The entire text has been reexamined and the prose updated and rewritten to improve its clarity. Chapter 10, Modern Atomic Theory, has been extensively revised. The fifth edition chapter on the Periodic Table has been integrated into the revised Modern Atomic Theory chapter and into Chapter 11, Chemical Bonds. Those instructors who feel it is essential to cover atomic theory and bonding early in the course can assign Chapters 10 and 11 immediately following Chapter 5.

In Chapter 19 we study the chemistry of selected elements from the viewpoint of the periodic table. Then in Chapters 20–27 we introduce organic chemistry, and finally look into the principles of biochemistry in Chapters 28–36.

We have added current, relevant examples to most organic and biochemistry chapters. Some extended additions include:

- a section on polymers and recycling (Chapter 26);
- a section on micelles, liposomes and lipoproteins (Chapter 29);
- a section on new sources for and uses of industrial enzymes (Chapter 31);
- a section on the Human Genome Project and gene therapy (Chapter 32);
- a section on the Nutrition Facts Labels found on packaged foods (Chapter 33).

We have reviewed and carefully selected organic reactions to illustrate the reactivities of each important functional group. Chapter 20 now introduces three general categories of organic reactions (substitution, elimination, addition). Where possible, subsequent chapters present reactions within this conceptual framework.

IUPAC nomenclature is emphasized in this edition, but we have also specifically considered how organics are named in everyday usage. Thus, we present a common name if it continues to be widely used.

Biochemistry has become an increasingly visual science. Molecular pictures are often essential to the understanding of biochemical functions. Chapter 30 (Amino Acids, Polypeptides and Proteins) has been rewritten to emphasize a three-dimensional structure-to-function relationship. Chapter 31 (Enzymes) stresses a qualitative and visual approach to enzymes.

Learning Aids

In revising *Introduction to General, Organic, and Biochemistry* we have included new features to enhance the presentation and clarity as well as reinforce the practical, everyday nature of chemistry. The new design uses color to identify study aids, and the illustrations have been chosen to emphasize chemistry in familiar surroundings. We include numerous learning aids to help students develop a growing confidence with technical and abstract scientific content.

- Important **terms** are set off in boldface type where they are defined, and are printed in blue in the margin. These terms are listed alphabetically under the heading **Key Terms** at the end of each chapter with section references to assist in review of new vocabulary, and are also printed in boldface type in the index.
- **Marginal Notations** have been added to help students in understanding basic concepts and problem-solving techniques. These are printed in magenta ink to clearly distinguish them from text and vocabulary terms.
- **Important statements**, equations, and laws are boxed and highlighted for emphasis.
- **Steps for solving problems** are printed in blue for easy reference.
- Worked **examples** with all steps included show students the how of problem solving before they are asked to tackle problems on their own.
- **Practice problems** permit immediate reinforcement of a skill shown in the example problem. Answers are provided at the end of the chapter to encourage students to check their problem solving immediately.

terms: pp. 47, 310–311, 756

Key Terms: pp. 80, 209, 850

marginal notations: pp. 262, 575, 963

boxed statements and equations: pp. 58–59, 745

steps for problem solving: pp. 149–150, 235, 539

worked examples and practice problems: pp. 17, 113, 696

answers to practice problems: pp. 396, 855

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end of chapter exercises:
pp. 80–82, 651–655

Concepts in Review: pp. 40,
209, 625

paired exercises: pp. 121–122,
813–814

additional exercises: pp. 190–
192, 872

Chapter 1 begins with a garden photo as the metaphor for the diversity of the material world, which chemistry seeks to understand, explain, and utilize (pp. 1–2). Chapter 14 opens with an illustration of a surfer in the ocean, which is an aqueous solution.

Chemistry in Action: See p. 135, *The Taste of Chemistry*, and p. 700, *Coffee Talk*

- **End of chapter exercises** have been significantly revised, with approximately 200 new exercises, many emphasizing concepts and applications. Many of the existing problems have been shortened to fewer parts.
- A list of **Concepts in Review** given at the end of each chapter guides students in determining the most important concepts in the chapter.
- This edition features **paired exercises** at the end of most chapters. Two parallel exercises are given, side by side, so the student can use the same problem-solving skills with two sets of similar information. Answers to the even-numbered paired exercises are given in Appendix V.
- **Additional Exercises** are provided at the end of most chapters. They are arranged in a more random order, to encourage students to review the chapter material.
- A **Review of Mathematics** is provided in Appendix I. (see p. A-1)
- **Units of measurement** are shown in table format in Appendix III and in the endpapers. (see p. A-12)
- **Answers** to the even-numbered exercises are given in Appendix V. (see p. A-15)
- **Each chapter opens** with a color photograph relating the chapter to our daily life. A chapter preview list assists students in viewing the topics covered in the chapter, and the introductory paragraph further connects the chapter topic to everyday life.
- Each chapter contains at least one special **Chemistry in Action** section that shows the impact of chemistry in a variety of practical applications. These essays cover such topical information as controlling graffiti and the fat content of fast food. Other Chemistry in Action essays introduce experimental information on new chemical discoveries and applications. Over twenty new essays have been added and the others carefully revised.

A Complete Ancillary Package

The following teaching materials have been developed to accompany this text.

For the Student

Study Guide by Peter Scott of Linn-Benton Community College and Rachel Porter of University of Illinois, Urbana-Champaign is a carefully revised self-study guide. A self-evaluation section presents a variety of exercises to the student, followed by answers and solutions. A recap section then concisely summarizes chapter concepts.

Solutions Manual by Morris Hein, Leo R. Best, Scott Pattison, and Susan Arena includes answers and solutions to all end-of-chapter questions and exercises.

Introduction to General, Organic, and Biochemistry in the Laboratory, 6th Edition, by Morris Hein, Leo R. Best, and Robert L. Miner, and James M. Ritchey includes 42 experiments for a laboratory program that may accompany the lecture course. Featuring updated information on waste disposal and emphasizing safe laboratory procedures, the lab manual also includes study aids and exercises.

A Basic Math Approach to Concepts of Chemistry, 6th Edition, by Leo Michels is a self-paced paperbound workbook that has proven itself an excellent resource for students needing help with mathematical aspects of chemistry. Evaluation tests

are provided for each unit and the test answers are given in the back of the book. A glossary is also included.

Brooks/Cole Exerciser (BCX) 2.0, by Laurel Technical Services is a text-specific software tutorial for general chemistry, with exercises from the main text and the Study Guide. The program monitors student progress and generates reports. This software is available for DOS, DOS/Windows, and Macintosh platforms.

Alchemist: A Chemical Equation Balancer for Macintosh, by Steve Townsend and Joyce Brockwell is a software tool for balancing complex chemical equations.

Beaker is a sophisticated, yet easy to use program for exploring organic chemistry principles, for studying and solving, sketching and analyzing molecular structures, for constructing NMR spectra, for performing reactions, and more. This software is available for Macintosh (*Beaker 2.1*) and DOS/Windows (*Beaker 2.2*).

Organic Chemistry Toolbox, by Norbert J. Pienta is a text-specific software tool for constructing molecular models, drawing Lewis dot structures, creating animations of reactions, solving chemistry problems, and studying structures. Available for DOS/Windows and Macintosh platforms.

For the Instructor

Printed Test Items with Chapter Tests for *Introduction to General, Organic, and Biochemistry, 6th Edition*, includes a copy of the test questions provided electronically in *EXP-Test*, Review Exercise Worksheets, answers to the test item questions, and answers to the Review Exercise Worksheets.

Instructor's Manual for Introduction to General, Organic, and Biochemistry in the Laboratory, 6th Edition, includes information on the management of the lab, evaluation of experiments, notes for individual experiments, and answer keys to each experiment's report form and to all exercises.

EXP-Test, a computerized test generation system, is available for IBM PCs or compatibles. A Macintosh version, *ESATEST III*, is also available.

Transparencies in full color include illustrations from the text, enlarged for use in the classroom and lecture halls.

Acknowledgments

It is with great pleasure that we begin these acknowledgments by thanking our colleagues and students for many helpful comments and suggestions. These are the people who have made this book possible and it is for them we write.

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Preface

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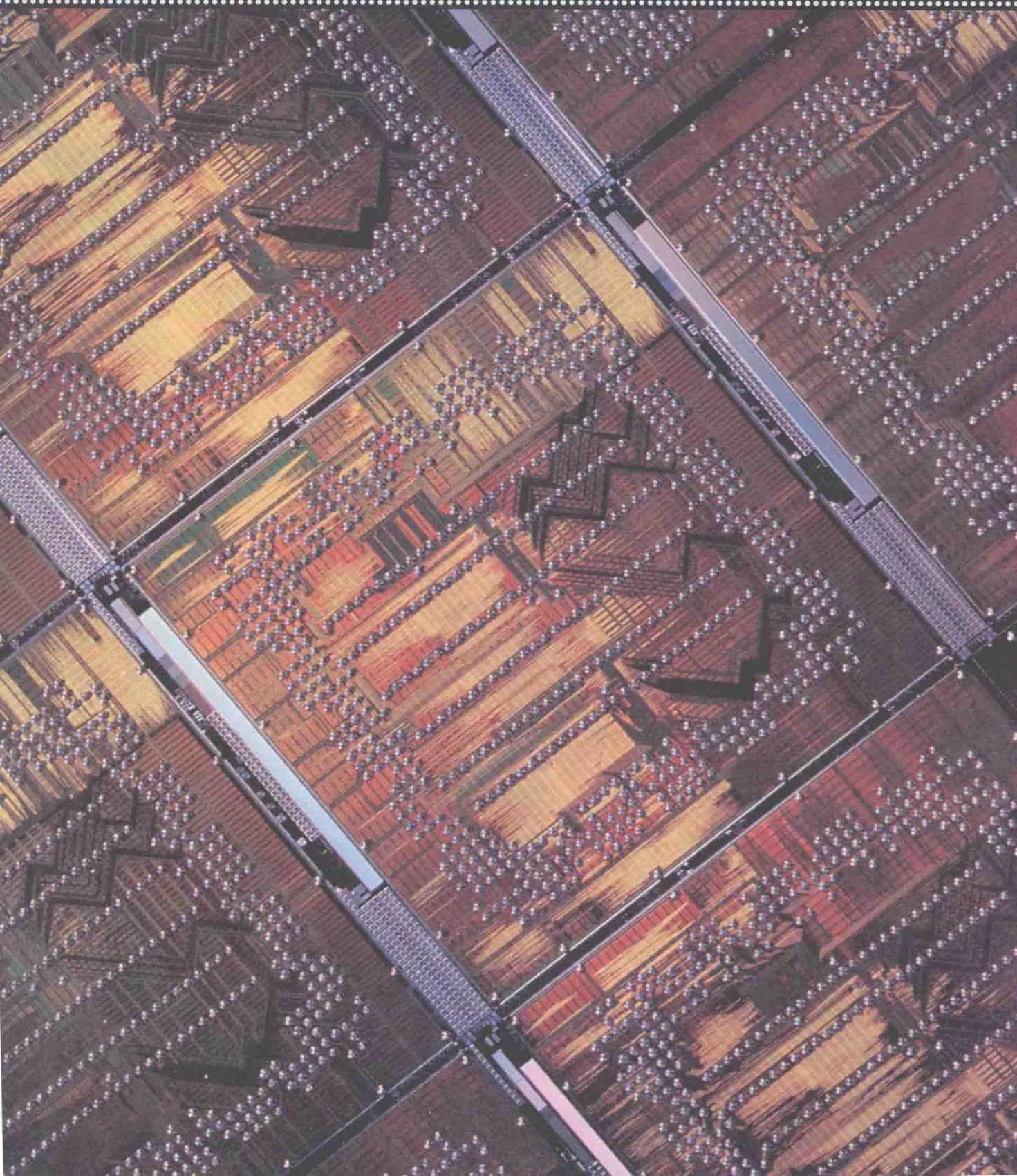
About the Authors

Morris Hein is professor emeritus of chemistry at Mt. San Antonio College, where he regularly taught general and organic chemistry. His name is synonymous with clarity, meticulous accuracy, and a step-by-step approach that students can follow. Over the years, more than two million students have learned chemistry using a text by Morris Hein. In addition to *Introduction to General, Organic, and Biochemistry, 6th Edition*, he is co-author of *Foundations of College Chemistry, 9th Edition*. He has also co-authored *Foundations of Chemistry in the Laboratory* and *College Chemistry in the Laboratory*.

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